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THE INFLUENCE OF STARLINGS ON FLICKER REPRODUCTION WHEN BOTH NATURALLY EXCAVATED CAVITIES AND ARTIFICIAL NEST BOXES ARE AVAILABLE

DANNY J. INGOLD[1]

ABSTRACT.—I monitored 54 pairs of Northern Flickers (*Colaptes auratus*), with artificial nest boxes placed near their nest cavities, during three breeding seasons in Ohio to determine whether such boxes would help reduce nest-site competition by European Starlings (*Sturnus vulgaris*). Twenty-seven of 40 flicker pairs in the presence of starlings (68%) lost a total of 42 cavities to starlings in spite of the presence of a nearby flicker nest box, and nine of these pairs lost two or more cavities to starlings. Thus, the presence of nest boxes did not appear to help nesting flickers and in fact may have deterred them by attracting additional starlings. During initial nest attempts, flicker pairs without starlings produced larger clutches, more nestlings and more fledglings than flickers with starlings. Flicker pairs without starlings were not adversely affected by the presence of a nearby nest box and 64% of such pairs eventually fledged young from their excavated nest cavities. Conversely, no pairs without starlings and only one pair with starlings opted to nest in a nest box versus their excavated or renovated nest cavity. Only 3 of 40 starling pairs opted to nest in a box when excavated flicker cavities were available. However, starlings eventually fledged young in only 9 of the 42 flicker cavities they usurped (21%).
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For several decades it has been documented that European Starlings (*Sturnis vulgaris*) usurp nest cavities from a variety of woodpecker species (Wood 1924; Shelley 1935; Bent 1939; Howell 1943; Dennis 1969; Erskine and McLaren 1976; Jackson 1976; Troetschler 1976; Short 1979, 1982; Weitzel 1988; Ingold 1989, 1994; Kerpez and Smith 1990), as well as from several secondary cavity-nesting species (Bent 1950, Zeleny 1969, Erskine and McLaren 1976, Feare 1984, Ingold and Ingold 1984). Ingold (1989) found that Red-bellied Woodpeckers (*Melanerpes carolinus*) nesting in the presence of starlings suffered reductions in their reproductive output as a result of starling harassment. Northern Flickers (*Colaptes auratus*), one of the largest woodpeckers in North America, are also commonly harassed by starlings (Kilham 1959, Sedgwick and Knopf 1990, Ingold 1994, Moore 1995). Moore (1995) suggested that although flickers frequently lose nest cavities to starlings early in the season, they often renest after starlings have completed initiating nest attempts. Since very few flicker nest cavities are usurped by starlings late in the season (Ingold 1994, Moore 1995), it may be that late-nesting flickers do not suffer reductions in fecundity as a result of starling harassment (see Ingold 1994). Ingold (1996), however, showed that late-nesting flickers in Ohio produced significantly smaller clutches, as well as fewer nestlings and fledglings compared to early-nesting flickers. Moreover, most of the successful early-nesting flicker pairs were those able to avoid starling competition. Ingold and Densmore (1992) and Ingold (1994) found that when flickers, Red-bellied Woodpeckers and Red-headed Woodpeckers (*M. erythrocephalus*) nesting in areas of starling overlap were forced to delay nesting, they often returned to nest in their original cavity or to another in the same tree.

Northern Flickers are sometimes considered weak excavators (Harestad and Keisker 1989, Winkler et al. 1995) and have been known to use wooden nest boxes for nesting (Bent 1939, Bower 1995). An inadequate supply of suitable nest sites limits the reproductive success of cavity-nesting birds (see Cline et al. 1980, Mannan et al. 1980, Nilsson 1984, Raphael and White 1984, Li and Martin 1991). When this occurs a nest box placed near a flicker nest cavity could provide a suitable alternative nest site for flickers or starlings competing for a flicker cavity. Gutzwiller and Anderson (1986) found that when suitable nest cavities were abundant, woodpeckers occasionally nested in the same tree at the same time with European Starlings. Ingold (1990) also reported Red-headed and Red-bellied

[1] Biology Department, Muskingum College, New Concord, Ohio 43762;
E-mail: Ingold@muskingum.edu

woodpeckers nesting in the same tree simultaneously with starlings.

In this study I placed a nest box designed for flickers (see Bower 1995) near all active flicker nest cavities early in the nesting season to determine if either starlings or flickers would take up residency in the box, thus conceding to the other species the flicker nest cavity. Since numerous studies have already documented that flickers lose excavated nest cavities to starlings (Sedgwick and Knopf 1990; Ingold 1994, 1996; see also Moore 1995), I did not compare flicker nest sites with and without boxes; rather, all sites had boxes and I compared sites with and without starlings. I then tested the null hypotheses that when nest boxes are established near active flicker nests there is no difference in the reproductive success of flickers nesting in the presence of starlings versus flickers nesting in the absence of starlings, and that there is no difference in the timing of nesting between flickers with and without starlings.

STUDY AREA AND METHODS

From late March through late July 1994–1996, I located active Northern Flicker nest cavities in and around New Concord, Muskingum Co., Ohio. Flicker nests were located most frequently in open woodlands and agricultural areas, but were also found in forested and residential areas (see Ingold and Densmore 1992, Ingold 1994 for a more detailed description of the study area).

Flickers were categorized as either being in the presence or absence of starlings. Pairs were considered to be starling-free if I did not detect starlings in a 0.25 ha circular plot around their nest cavity throughout the nesting season (see Ingold 1989, 1994). Although this method of categorization is not fool proof, since most flickers I considered to be starling-free were found in more forested areas and because I monitored all nest sites at least once and frequently twice a week, the criterion used to define such pairs is fairly sound. I erected a nest box designed for flickers similar to the one described by Bower (1995) within 0.5–2.0 m of all active flicker cavities (both with and without starlings) that were still being excavated or in which flickers had begun egg laying. Depending on the diameter of the tree and the height of the cavity, boxes were attached either above, below, or in some instances beside the cavity ($\bar{x}$ height of boxes = 6.5 m; n = 41). Boxes were oriented so that the entrance was facing in about the same direction as the entrance of the flicker cavity. I did not attach a nest box next to active cavities in which the flicker nesting effort had progressed to the incubation or nestling stage, since by this point most flicker pairs were not in danger of losing their cavities to starlings. During 1994 I placed cedar woodchips or planer shavings at the bottom of each nest box to encourage flicker occupancy. During 1995–1996 I filled the boxes up to the cavity entrance with cedar woodchips to further encourage flicker use (see Bower 1995).

I monitored each nest box and active woodpecker nest cavity for a minimum of 30 min each week between 07:30 and 18:00 EDT to determine their status and to detect possible starling/flicker interactions. Nest sites at which flickers and starlings were both present were monitored up to 90 min each week. Because I was seldom at a nest site when starlings took over, I considered a flicker cavity to be usurped when two criteria were met: (1) if I observed starlings in the cavity or if there was evidence that starlings occupied the cavity (such as fecal material around the cavity entrance and/or grass and leaves inside the cavity), regardless of whether or not they subsequently nested in the cavity, and (2) if the flicker pair did not return to occupy the nest cavity within a two week period after the date recorded for the initial takeover. Flicker cavities and nest boxes that became inactive for more than four consecutive weeks during the study were not monitored during the remainder of the nesting season. Starlings that initiated nest attempts in boxes after having usurped a flicker cavity, were allowed to continue nesting if the flickers were subsequently detected in the same ~1.0 ha circular plot around the cavity tree, to ascertain whether the flicker pair would return to their original nest cavity.

A total of 41 nest boxes were erected during the study (20 in 1994, 14 in 1995, 7 in 1996). In some instances flicker pairs lost multiple cavities to starlings in the same cavity tree during the same year. In such instances, I erected a new nest box next to each new flicker cavity and treated it as a new observation. Thus, some snags or cavity trees had more than one nest box attached to them. Previously excavated flicker nest cavities or boxes that were used by flickers in subsequent years (n = 13) were also treated as new observations. Data were collected from a total of 54 flicker pairs during the three-year period (16 in 1994, 25 in 1995, 13 in 1996).

Using a 10-m extension ladder, I climbed to those active flicker cavities that I could reach once or twice weekly and examined the contents with a light and mirror. I considered the clutch size to be the number of eggs present at the onset of incubation. I considered the number of nestlings to be the number of eggs that hatched regardless of the number of nestlings that eventually fledged. I considered the number of fledglings to be the number of nestlings that were present in the cavity upon my last visit (see Ingold 1996).

Because the number of flicker nests from which I obtained clutch sizes, nestling numbers, and fledgling numbers was small (n = 3, 4, and 2 nests without starlings and 7, 9, and 5 nests with starlings from 1994–1996 respectively), I pooled these data across years. Once pooled, I divided clutches into early nests (those completed before 1 June, the date by which at least 90% of uninterrupted flicker pairs had initiated their first clutch) and late nests (completed after 1 June, by which time second nest attempts were common, usually as the result of a failed first nest attempt; see Ingold 1996). I used *t*-tests to test for differences in clutch size, nestling numbers, and fledgling numbers between nests with and without starlings, and between early and late nests; however, in several instances in which the data were not normally distributed, I used Mann-Whitney Rank Sum Tests. All statistical analyses were performed with Sigma Stat, ver. 1.0 on a PC computer.

The number of flicker cavities usurped by starlings was small, and the number of cavities usurped relative to the number of cavities that were available varied only minimally among years. Thus, these data were pooled. I used a regression analysis to determine if the number of flicker cavities usurped relative to the number of cavities that were available was associated with the progression of time.

Differences in the timing of nest excavation, incubation, and the presence of nestlings and fledglings in flicker pairs with and without starlings were tested among years using Kolmogorov-Smirnov tests. Because no differences were detected ($P > 0.05$) and since my sample sizes were relatively small (3, 8, and 3 pairs without starlings and 13, 17, and 10 pairs with starlings from 1994–1996 respectively), I pooled these data.

RESULTS

Flicker response.—Nest starts by flicker pairs both in the presence and absence of starlings occurred from mid-April through early May (Fig. 1). Thirteen flicker pairs with starlings (32.5%) were still excavating nest cavities during the final week of May, compared to 2 flicker pairs without starlings (14.3%; Fig. 1). Although this difference is not significant ($\chi^2 = 3.16$, df = 1, $P > 0.05$), a significantly greater proportion of flicker pairs with starlings versus without starlings ($\chi^2 = 9.21$, df = 2, $P < 0.05$) were still rearing nestings in June and July (Fig. 1). Twelve of 14 flicker pairs without starlings (86%) produced clutches in their original nest cavities while none undertook a nest attempt in a nearby nest box instead of their nest cavity. Nine flicker pairs without starlings (64%) eventually fledged at least one young during their first nest attempt.

Twenty-seven of 40 flicker pairs in the presence of starlings (68%) lost their nest cavities to starlings despite the presence of nearby nest boxes. Of these, 18 flicker pairs appeared to have lost no more than one cavity each to starlings, six pairs lost at least two cavities to starlings, one pair lost three cavities, one pair lost four cavities and one pair lost five cavities. A significantly smaller proportion of flicker pairs with starlings fledged young during their initial nest attempt versus pairs without starlings (8 of 40 vs 5 of 14 respectively; 20% vs 36%; $\chi^2 = 7.49$, df = 1, $P < 0.01$). Flicker pairs without starlings produced significantly larger clutches than pairs with starlings ($t = 2.16$; df = 28; $P < 0.05$); mean nestling and fledgling numbers of pairs without starlings were also

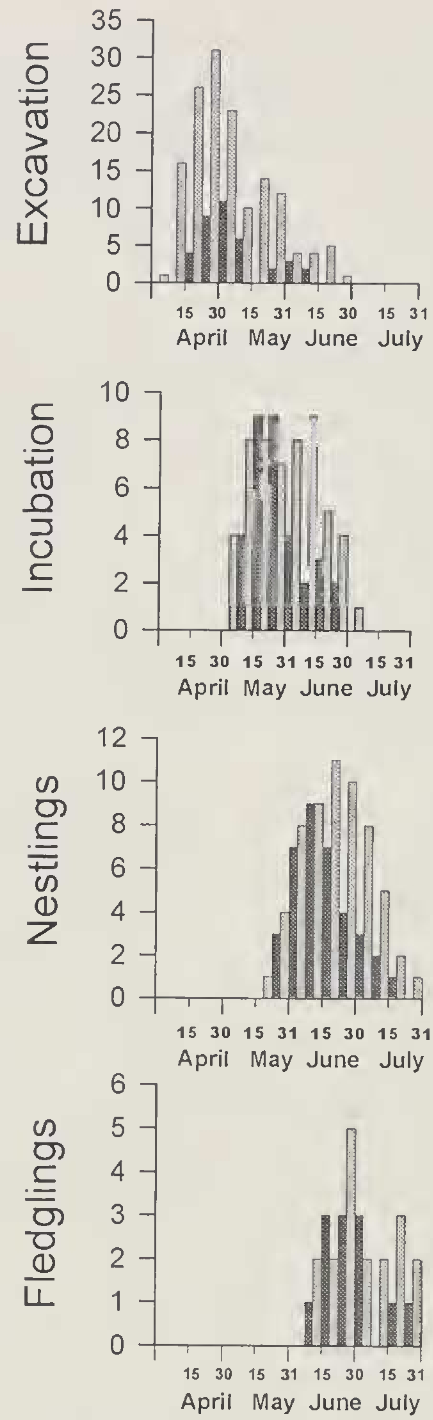

FIG. 1. Nesting pheonology of flicker pairs with boxes in the presence (light bars) and absence (dark bars) of starlings during 1994–1996 (n = 14 and 40 respectively; weeks on x-axis; number of flicker pairs on y-axis).

TABLE 1. Comparison of the reproductive success of flicker pairs in the presence and absence of starlings. Because of small sample sizes, reproductive data for all three years were combined. Differences in clutch sizes, nestling numbers and fledgling numbers were examined using *t*-tests.

	Starlings absent			Starlings present			
Variable	*n*	Mean	SD	*n*	Mean	SD	*P*-value
Clutch size	9	7.44	2.24	21	5.43	2.38	0.039
Nestlings produced	9	5.56	2.46	21	3.86	2.76	>0.05
Fledglings produced	9	3.78	2.99	21	2.57	2.64	>0.05

larger than pairs with starlings, but not significantly so (Table 1). When I divided flicker clutches into early versus late nests, clutch size, nestling numbers and fledgling numbers from early nests were significantly larger than those from late nests ($P < 0.05$ in each case; Table 2). Moreover, at least 90% of late-nesting flicker pairs encountered starling harassment early in the nesting season. Only one experimental flicker pair undertook a nest attempt in which eggs were laid in the nearby nest box. This particular pair lost its excavated nest cavity to starlings and moved to the nest box where they eventually fledged four young. The starlings at this location abandoned the excavated nest cavity they usurped and disappeared from the area.

With the progression of time, the number of flicker cavities usurped by starlings decreased significantly ($F = 26.8$, $P < 0.001$, $df = 1,8$; Fig. 2). At least 10 of 27 flicker pairs (37%) that lost cavities to starlings in April and early May returned to nest in the same 0.25 ha circular plot, often in the same tree or nest cavity, in late May or June.

Starling response.—Starlings used a nest box at only 3 of 40 flicker nest sites (7.5%) rather than attempt to usurp the flicker nest cavity or move elsewhere to nest. In each instance, both the starlings and flickers successfully fledged young from nests in close proximity to each other. At 10 flicker cavities (25%) starlings neither usurped the active flicker cavity nor used the nest box, and at five of these locations (50%) the flicker pair eventually fledged young. Starlings laid eggs in at least 15 of the 42 (36%) flicker cavities they usurped but fledged young in only nine (21%). At eight of the usurped cavities (19%), starlings subsequently laid eggs in the nearby nest box rather than in the cavity, and in four instances (9.5%) they laid eggs in both the usurped nest cavity and the nearby flicker nest box. In all of the latter four instances more than one starling pair was involved.

Interspecific use of nest-box trees.—At 13 nest-box locations, two or more different species undertook nest attempts (in which eggs were laid) in the nest box and/or in cavities in the same tree at the same time. At five locations, one pair of flickers and one or more pairs of starlings were undergoing egg-laying or incubation at about the same time. In three instances, starlings used the nest box while flickers used a nearby cavity; in all three instances both the starlings and flickers fledged young. At a fourth location, a pair of incubating flickers lost their nest cavity to starlings, while a pair of starlings had eggs in the nearby nest box. It was unclear whether it was the starling pair with eggs that usurped the nearby flicker nest cavity or another starling

TABLE 2. Comparison of the reproductive success of early-nesting flickers (clutches completed before 1 June) and late-nesting flickers (clutches completed after 1 June). Because of small sample sizes, reproductive data for all three years were combined. Because the data did not meet the assumption of normality, they were examined using Mann-Whitney Rank Sum tests.

	Early nesting Flickers			Late nesting Flickers			
Variable	*n*	Mean	SD	*n*	Mean	SD	*P*-value
Clutch size	22	7.18	2.08	9	4.56	2.07	0.003
Nestlings produced	22	4.86	2.96	10	3.20	2.30	0.048
Fledglings produced	22	3.64	2.77	10	1.70	2.26	>0.05

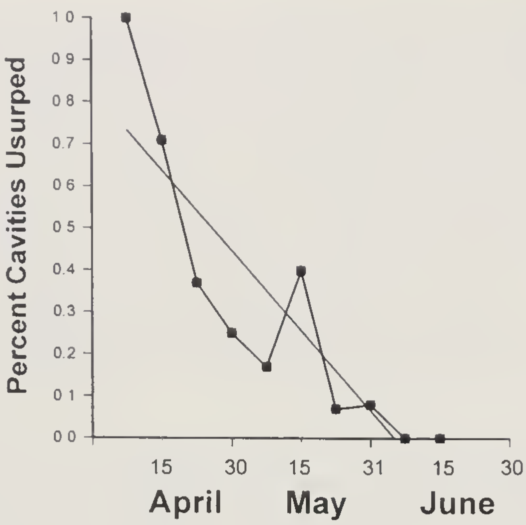

FIG. 2. The relationship between time and the proportion of flicker cavities usurped by starlings (Least Square fit: $Y = 7.96 - 8.08\times$; $r^2 = 0.770$; $P < 0.001$) during 1994–1996.

pair. At a fifth location in late May 1995, I found three flicker eggs and two starling eggs in the same flicker cavity at the same time. A week later all the eggs were gone; starlings returned within a few days, however, and initiated a new clutch in the flicker cavity.

At five locations, a pair of flickers and a pair of Red-headed Woodpeckers nested in the same tree simultaneously. In four instances, both species successfully fledged young, and in the process, generally did not interact with each other. At two of these locations the flicker and Red-headed Woodpecker pairs did not complete nesting until mid- to late July as a result of starling harassment earlier in the nesting season. In no case did either species use a nest box rather than an excavated nest cavity.

At one of the 13 locations of simultaneous interspecific use, a pair of American Kestrels (*Falco sparverius*) laid eggs in the flicker nest box while several pairs of starlings were incubating clutches in the same snag. Within a week the kestrel clutch disappeared and starlings had built a grass nest inside the box. At another location, starlings and Red-headed Woodpeckers nested in the same snag at about the same time and both successfully fledged young in June. I witnessed only a few competitive interactions at this location between these species. At the thirteenth location I found 7–8 pairs of nesting starlings, one pair of Pileated Woodpeckers (*Dryocopus pileatus*) and one pair of nesting flickers in the same snag at the same time. Most of the starlings, including occupants of the nest box, fledged young at this location by the end of June. The pileated pair fledged offspring during the first week of June, apparently without encountering any starling harassment. The flicker pair lost five nest cavities to starlings from late April through mid-June before successfully undertaking a nest attempt in late June. The pair eventually fledged young in late July in one of the nest cavities that starlings had usurped earlier in the season.

DISCUSSION

Flicker response to boxes.—Based on the prevalence and intensity of starling/flicker nest-site competition in this study, it appears that suitable nest cavities were in short supply; nonetheless, flicker nest boxes attached near active flicker nest cavities did not alleviate starling nest-site competition. In fact, flickers lost nest cavities to starlings at a much higher rate (68%) than Ingold (1994) reported (14%) for this species in this area from 1990–1992. This disparity may be due in part to a difference in methodology between the studies. Previously, I (Ingold 1994) did not distinguish between flickers in the presence and absence of starlings, and may have observed a greater number of starling-free flickers in the earlier study. Further, nest boxes, which may have attracted additional starlings to flicker nest sites in this study, were not erected in the 1990–1992 study. Finally, flicker populations in the eastern United States have been declining during the past ten years (Moore 1995), while starling populations have been stable or increasing, particularly in the Great Lakes region (Cabe 1993). This trend, coupled with the possibility that suitable flicker nest substrates including snags and dead limbs are declining, could be resulting in fewer flicker nest cavities and greater starling/flicker nest-site competition.

Flickers, in the presence or absence of starlings, appeared to show little interest in nest boxes. Only 1 of 27 flickers pairs that lost nest cavities to starlings initiated a nest attempt in a nearby nest box. This may be explained in part by the fact that starlings often reacted aggressively toward flickers when they came too close to a usurped nest cavity. It may be that nest boxes, typically situated 1–2 m from a flicker cavity, were within the territory that a starling defends when initiating a nest attempt. In addition, several starling pairs were often present at a cavity tree, and even after one starling pair usurped the flicker nest cavity, a second or third pair would often temporarily or permanently occupy the nest box, thus discouraging flickers from using the box. Bower (1995) reported that flickers nested successfully in the box he erected only after he shot several starlings that attempted to take over the box.

Only 1 of 14 flicker pairs in the absence of starlings opted to use a nest box rather than excavate a new nest cavity or renovate an old excavated cavity or knot hole. Although boxes were not erected until the flicker pair had initiated cavity excavation or renovation, flickers in the absence of starlings did not use them even after they had been in place for one or two years. This suggests that flickers had little inclination to use the boxes regardless of the availability of natural nest sites, or that in the absence of starlings (i.e., more densely forested areas), suitable nest trees or cavities may have been more common, and thus additional nest sites were unnecessary. Although flickers are not considered strong excavators (Bent 1939, Winkler et al. 1995), it appears that when given a choice, they prefer to excavate their own nest cavity in a snag or dead limb, or use a previously excavated or natural cavity than take up residency in a nest box. Bower (1995) and Jackson (1997) make several suggestions regarding the construction of nest boxes that might expedite their use by flickers. Bower (1995) suggests, however, that unless one is willing to control starlings and House Sparrows (*Passer domesticus*), it is unlikely that such boxes will attract flickers.

Although flickers generally avoided nesting in a box placed near their cavity or cavity start, the boxes in the absence of starlings did not appear to disturb them or deter them from carrying on their normal nesting activities. Eighty-six percent of starling-free flickers produced clutches and 64% eventually fledged young from cavities, even with a nest box situated nearby. Conversely, in the presence of starlings, with a single exception, nest boxes did not provide a suitable alternative nest site for flickers. However, aside from their common need to secure and defend a nest cavity, the ecological niches of starlings and flickers overlap relatively little. Once starlings in this study obtained a suitable nest cavity and initiated egg-laying, they generally ignored other cavity nesting species that took up residency in nearby cavities. Similarly, nesting flickers generally ignored nearby starlings once the latter had begun egg laying. Gutzwiller and Anderson (1986) and Ingold (1990) also reported that starlings and woodpeckers nested peacefully in proximity of each other after each pair had established control of their nest cavity and initiated egg laying.

Starling response to boxes.—Data in this study suggest that European Starlings prefer to usurp active flicker nest cavities, whether freshly excavated, previously excavated or knot-hole cavities, rather than undertake a nest attempt in a seemingly suitable nearby nest box. Only 7.5% of starlings chose to nest in a box rather than usurp an available flicker cavity or move to another location. In eight instances, starlings laid eggs in the nearby nest box rather than in the flicker cavity they usurped, and in four additional instances starling pairs initiated nest attempts in both the usurped flicker cavity and the nearby nest box. Although starlings are undoubtedly nest-site generalists that are willing to nest in cracks and crevices of buildings, old knot-hole cavities, old excavated cavities and nest boxes (Bent 1950, Zeleny 1969, Dakin 1984), data are accumulating that support the hypothesis that they prefer freshly excavated woodpecker cavities over many of the alternatives (see Ingold 1989, 1994; Kerpez and Smith 1990). However, an enigma remains. Although starlings usurped 42 active flicker nest cavities, they subsequently fledged young in only nine of them (21%). Of 32 woodpecker nest cavities usurped by starlings in east-central Ohio in 1990–1992, starlings subsequently abandoned 22 (69%) of them before initiating egg laying (Ingold 1994). Thus, although starlings seem to show a preference for freshly-excavated woodpecker cavities for nesting, they frequently fail to nest in the cavities they usurp. One possible explanation for this is that starlings sometimes drive away a woodpecker pair before it has completed excavating the nest cavity. I observed two nest cavities in this study and many in other studies that were taken over by starlings before completion. In each of these instances, starlings abandoned the cavities probably because they were not deep enough. Nonetheless, there were several additional instances in this study and in past studies (Ingold 1989, 1994) in which I observed starlings usurp a completely excavated flicker nest cavity and then abandon it after building a partial or complete nest inside. It could be that excavating woodpeckers and/or the presence of freshly excavated cavities act as stimuli that activate aggressive starlings during the peak of their breeding season. Some starlings may be young and inexperienced nesters and simply fail to undertake a successful nest attempt in the usurped cavity. Clearly further research should be undertaken to address this "stimulus" hypothesis.

Implications for flicker reproduction.—Ingold (1994) suggested that although flicker pairs lost nest cavities to starlings, they may not have suffered reductions in their reproductive output, because these pairs often returned to their original cavity tree to nest successfully later in the season. Indeed the flicker nesting season may extend through July in Ohio, although the peak of their nesting effort occurs from early May through early June throughout most of their geographical range (Moore 1995). In this study, several flicker pairs in areas of starling overlap (at least 37%) that lost nest cavities to starlings in late April and early May, undertook a second nest effort in June or July, often in the same cavity tree or in another tree in the immediate area. However, the fecundity of late-nesting pairs was lower than that of starling-free pairs; moreover, when I arbitrarily divided all clutches into those completed before and after 1 June, the early nesters produced significantly more offspring. Ingold (1996) reports that early clutches, nestling numbers and fledgling numbers from flicker pairs studied from 1990–1992 and 1994–1995 in this area also were significantly larger than clutches, nestling numbers and fledgling numbers from late-nesting pairs. Thus, although flickers may routinely renest later in the season if their initial effort is disrupted (see Short 1982, Moore 1995, Winkler et al. 1995), they may still be at a reproductive disadvantage since their fecundity is reduced as the nesting season progresses. It is probable therefore, that flickers are subjected to opposing selection pressures. On the one hand, starling competition early in the season could select for delayed nesting; on the other hand, the detrimental effects of later nesting (i.e., warmer temperatures, less food and less time for the young to mature before winter) should select for early nesting (see Ingold 1996). The stronger of these selection pressures remains to be determined; even so, it is clear that European Starlings are having a significantly adverse effect on the reproductive success of Northern Flickers in Ohio.

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